

THE DEVELOPMENTAL STAGES OF LABIDOCERA

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INTRODUCTION

Within the past year there has been an increased effort directed towards the study of the development and life histories of marine copepoda. Five publications have recently appeared (Nicholls, 1934; Gurney, 1934; Campbell, 1934; Johnson, 1934*a*, 1934*b*) describing in detail the development of a total of seven marine calanoids. Prior to these works only nine species of this group had been investigated as to their complete development. Gurney (1934) has attributed this lag in investigation of the development of this, the most important of the marine plankton copepod groups, to the difficulty experienced in laboriously tracing out the life histories from the various stages as collected from the plankton, a difficulty further enhanced by the failure of many species to carry eggs. More success has been obtained in the study of fresh water calanoids, due to the greater ease with which they may be cultured in the laboratory. Thus far only one marine calanoid (*Calanus finmarchicus*) has been successfully reared through all the stages to the adult (Lebour, 1916). Gibbons (1933) has cultured this species through the nauplius stages. *Euchaeta norvegica* has been reared through the nauplius stages into the first copepodid; the nauplii apparently being sustained by a large store of yolk (Nicholls, 1934).

The species included in the present study are *Labidocera trispinosa* and *Labidocera jollæ*, which were described by Esterly (1905, 1906) from plankton collections made off the southern California coast. The former is reported as fourth in abundance of the copepods occurring in this region, and is at times very numerous above one hundred fathoms (Esterly, 1912). It is evidently more or less sporadic in occurrence and is found only sparsely in inshore collections. *Labidocera jollæ* is relatively more scarce, judging from the infrequent reference to it in Dr. Esterly's works. My inshore collections indicate that its nauplius stages are as a rule less numerous than those of *Labidocera trispinosa* and that the two species reproduce concurrently during the summer and autumn, and to a lesser extent well into winter. The spring season has not been investigated.

These are the only two species of *Labidocera* reported from this region. The nearest relative whose nauplius larvae might on superficial examination be confused with those of the present species is *Epilabidocera amphitrites*. This species, however, has not been found south of San Francisco Bay and its larval stages are known (Johnson, 1934b) and can on careful examination be quite readily distinguished from the present species.

In a preliminary investigation of the seasonal occurrence of zoöplankton at La Jolla, Murphy (1924) concluded that 70-80 per cent of the total plankton was made up of immature forms whose generic identity is not known. Copepod nauplii formed the major part of this percentage, but to what extent the present species of *Labidocera* entered into the computations is not known. Thus far I have found them to play only a minor rôle in local inshore waters.

PROCEDURE

The material used in the present study was obtained from surface plankton collections taken at the Scripps Institution pier. *Labidocera jolla* female copepodid V was, however, found only in an offshore collection put at my disposal through the courtesy of Dr. E. G. Moberg. This collection also provided material for checking the adult stages of both species. Both living and preserved specimens were employed in working out the successive stages. The identity of the larvae was established by experimentally rearing the last nauplius stage through the critical moult to the first copepodid stage and linking this with the successive copepodid stages to the adult, which proved to be of the genus *Labidocera*.

The nauplius larvae of the two local species of *Labidocera* are separable on small but consistent specific characters mentioned later. A total of six specimens of the last nauplius stage of *Labidocera trispinosa* were reared through the critical moult and the resulting first copepodid examined by complete dissection. Four specimens of *Labidocera jolla* were thus reared and examined, and many specimens of both species were examined from plankton collections. It is interesting to note that the specific differences appear no greater in the first copepodid stage than in the preceding nauplius stage, but in the following instars the species are easily separated by the clearly visible cephalic hooks present in *Labidocera jolla* but wanting in *Labidocera trispinosa*, and by the longer first antennae of the latter species.

All drawings were made with the aid of a camera lucida.

LABIDOCERA TRISPINOSA

The Nauplius Stages

The early development is divided into the characteristic six nauplius stages. Pronounced specific differentiation does not appear until the second stage, and each following moult accentuates or brings to light new differentiations.

Contrasted with nearly all copepod nauplii, the larvae of *Labidocera trispinosa* and *Labidocera jollæ* are noticeably elongated. This elongation is, however, only of an intermediate nature when compared with the elongation of the later larvæ of such forms as *Rhincalanus* (Gurney, 1934, Figs. 3, 4, 5) and a local larva tentatively classified as *Pontellopsis occidentalis*. The appendages of *Labidocera trispinosa* are also relatively long and the first antennæ are normally directed straight forward and in contact nearly their whole length. In the later nauplius stages the distal segment of the first antenna is faintly orange in color; the color increasing in intensity toward the tip. Similar pigment is also present in the second antenna, but here the greatest intensity is in the first basipod. The mandibles are nearly colorless. A little of the pigment is visible on the ventral surface of the body and in the alimentary canal where a small splash of red also appears in some specimens. The eye is very dark reddish-brown. The general pigmentation is quite variable in intensity and specimens that have been kept alive in the laboratory a day or longer may become quite colorless.

The labrum is long and rather wide and only very sparsely armed with short weak setæ.

The plumose nature of the appendage setæ can in some instances be seen only with difficulty and is here indicated only in the figures for the sixth nauplius stage.

Nauplius Stage I (Plate I, Fig. 1)

Body.—0.13–0.14 mm. long, oval, posterior end bearing two small spines.

First antenna (Plate IV, Fig. 5).—Three segments, the first short and with one short ventral seta; the second somewhat longer and bearing ventrally one very short and one long seta; the third or distal segment bearing terminally three long setae and ventrally near the tip a short spine.

Second antenna.—First basipod with one small masticatory hook. Second basipod with one small masticatory hook and an adjacent small outwardly directed spine. Endopod of one segment with two

terminal setae and one lateral seta. Exopod of six segments, the first two fused, the first with no seta, 2-5 with one seta each and the sixth with two setae.

Mandible.—First basipod with a small rounded chewing process bearing a small spine. Second basipod with two inner spines. Endopod of two completely fused segments indicated only by the presence of three short weak spines on the first and one very short and two long setae on the second. Exopod of four segments, 1-3 with one seta each, the fourth with two setae.

Nauplius Stage II (Plate I, Fig. 2)

Body.—0.175-0.201 mm. long (average of 11 measurements, 0.185 mm.) terminating posteriorly in one long heavy setose spine and one shorter dorsally directed plumose seta at its right. Partially surrounding the base of each of these is a number of very short fine spines.

First antenna (Plate IV, Fig. 6).—The first and second segments as in I; the distal segment bears at the tip three long plumose setae and one shorter, lighter accessory seta and the dorsal and ventral margins each bear a separate row of fine hair-like setae.

Second antenna.—The first basipod with one masticatory hook. Second basipod with one long heavy masticatory hook, an adjacent small outwardly directed spine and one small spine situated distally near the endopod. Endopod with three long terminal setae and one long lateral seta bearing a small smooth process near its proximal end. Exopod as in I but with two setae on the second segment.

Mandible.—First and second basipods as in I. Endopod as in I but with increased strength of armature. Exopod as in I but with two setae on the first segment indicating a segmentation which remains latent until the first copepodid stage is reached.

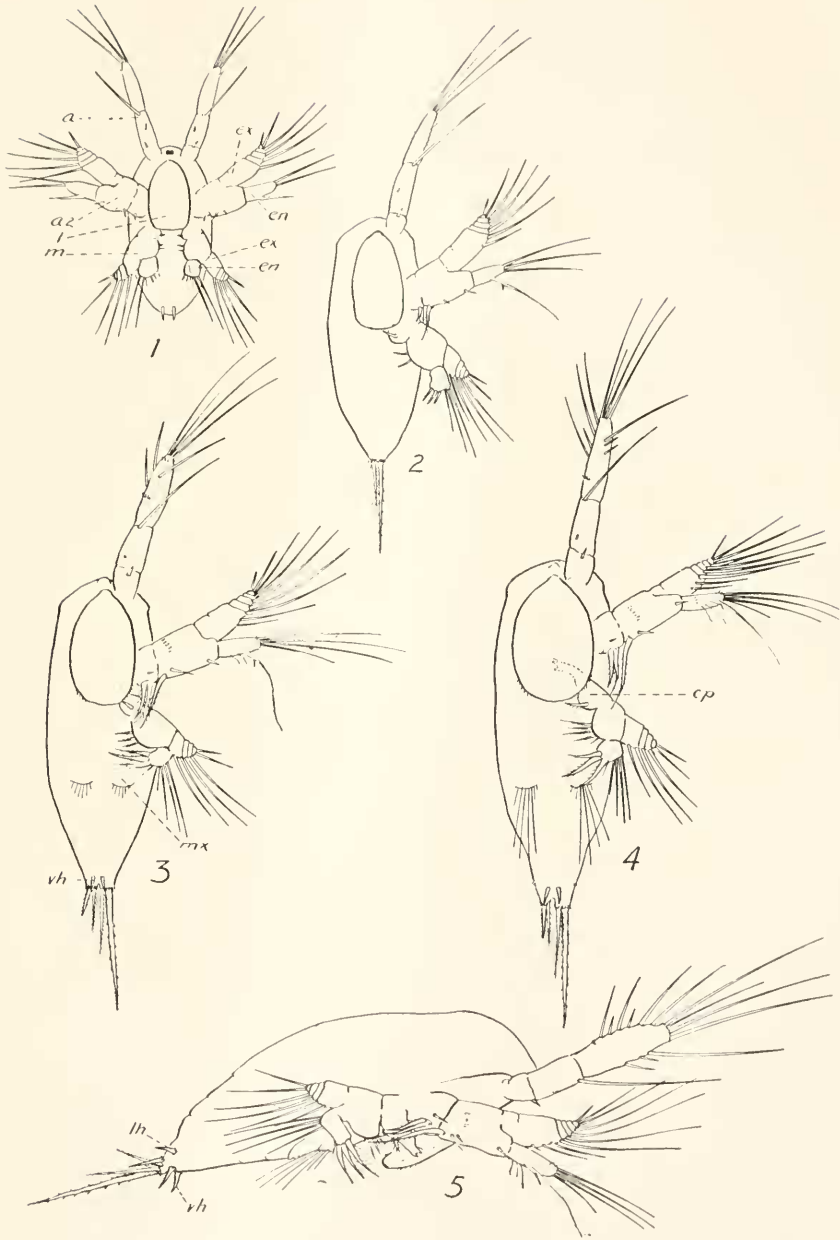
EXPLANATION OF PLATE I

Labidocera trispinosa

- FIG. 1. Nauplius Stage I.
 FIG. 2. Nauplius Stage II.
 FIG. 3. Nauplius Stage III.
 FIG. 4. Nauplius Stage IV.
 FIG. 5. Nauplius Stage V.

Abbreviations: <i>a</i> —first antenna.	<i>l</i> —labrum.
<i>a2</i> —second antenna.	<i>lh</i> —lateral hook.
<i>cp</i> —chewing process.	<i>m</i> —mandible.
<i>en</i> —endopod.	<i>mx</i> —first maxilla.
<i>ex</i> —exopod.	<i>vh</i> —ventral hook.

PLATE I



Nauplius Stage III (Plate I, Fig. 3)

Body.—0.215–0.271 mm. in length (average of 23 measurements, 0.235 mm.). Posterior end armed with one long left and one short right terminal setose spine, and one flexible inner plumose seta in conjunction with each spine. Just anterior to the terminal armature there is now one pair of ventral hooks.

First Antenna (Plate IV, Fig. 7).—Segments one and two as in II, the distal segment with four terminal setae, two long dorsal marginal setae, one long ventral marginal seta, and a transverse series of minute spines on the inner margin near the middle. The fine hair-like setae found on the distal segment in II are now wanting.

Second Antenna.—First basipod with two long strong masticatory hooks upon a common base and adjacent to these one small spine. Second basipod as in II but with also a transverse series of minute spines situated on the ventral proximal portion of the segment. Endopod as in II but with four terminal setae and two additional fine hair-like setae near the origin of the single long lateral seta. Exopod as in II but with three setae each on the second and terminal segments.

Mandible.—First basipod as in II. Second basipod with three inner spines. Endopod with three strong hook-like spines and one very weak basal seta on the first segment and four slender setae on the second segment. Exopod as in II.

First Maxilla.—Bud fringed with short hairs, discernible only with difficulty in some specimens.

Nauplius Stage IV (Plate I, Fig. 4)

Body.—0.250–0.325 mm. long (average of 14 measurements 0.278 mm.). The caudal armature is like that in Stage III with the addition of a series of minute lateral spines marking the location where the lateral hooks are destined to appear in the following stage.

First Antenna (Plate IV, Fig. 8).—First and second segments unchanged; distal segment with four terminal setae, one short and three long dorsal marginal setae, one long and two short ventral marginal setae and a transverse series of minute spines on the inner side.

Second Antenna.—First and second basipods as in III. Endopod as in III but with also a few very minute spines grouped on the lateral surface. Exopod as in III.

Mandible.—First basipod with the chewing process much enlarged and terminating in two teeth and a small lateral seta. Proximally the process bears a heavy setose spine. Second basipod with five inner spines. Endopod and exopod as in III.

First Maxilla.—Bud with slender weakly chitinized setæ.

Second Maxilla.—Poorly defined bud. (Visible only in some specimens nearing ecdysis.)

Nauplius Stage V (Plate I, Fig. 5)

Body.—0.310–0.370 mm. in length (average of 14 measurements, 0.332 mm.). Posterior end armed as in IV but including also one pair of lateral hooks similar to the ventral pair.

First Antenna (Plate IV, Fig. 9).—Unchanged except for increase to four long and two short (alternating with the long) dorsal marginal setæ and one long and two short ventral marginal setæ.

Second Antenna.—First basipod unchanged. Second basipod unchanged but for addition of one very small spine adjacent to the masticatory hook, thus making two small spines in this location. Endopod as in IV but with three fine hair-like setæ near the base of the single long lateral seta. Exopod as in IV but with four setæ on the second segment.

Mandible.—As in IV.

First and Second Maxilla.—Rudimentary.

Maxilliped.—Bud.

Nauplius Stage VI (Plate II, Fig. 1)

Body.—0.360–0.420 mm. long (average of 11 measurements, 0.386 mm.). Caudal armature as in Stage V. Just anterior to the lateral hooks there is on each side a series of very minute lateral spines. The rudimentary legs which in some specimens of Stage V can be seen as blocks of undifferentiated tissue are now quite distinct, but the first maxillæ are still poorly defined.

First Antenna (Plate IV, Fig. 10).—As in Stage V but with a total of five ventral marginal setæ on the distal segment.

Second Antenna.—First and second basipods as in V. Endopod as in V but with a total of five terminal setæ. Exopod as in V.

Mandible.—As in Stage V but with increased strengthening of the masticatory portions and with a total of six setæ on the inner margin of the second basipod.

First and Second Maxilla.—Rudimentary.

Maxilliped.—Bud.

First and Second Legs.—Rudimentary.

The Copepodid Stages

Following the critical moult there is a succession of six copepodid stages, the last of which is the adult animal. Living animals display a

rather faint dark orange coloration of the first and second basipods of the second antennae, and some of this pigment is also evident in the posterior end of the body. A few dark spots occur along the mid body and a faint green is noted along the alimentary canal. The color intensity varies greatly and is usually more pronounced in the older specimens.

From the first copepodid stage, the animals swim in the fashion apparently typical of the *Pontellidae*, i.e. with quick sweeps of the second antennae and with rhythmic dorsal ventral motion of the urosome. Thus, when swimming leisurely, the animal gives the appearance of a hovering bird.

Copepodid Stage I (Plate II. Fig. 2)

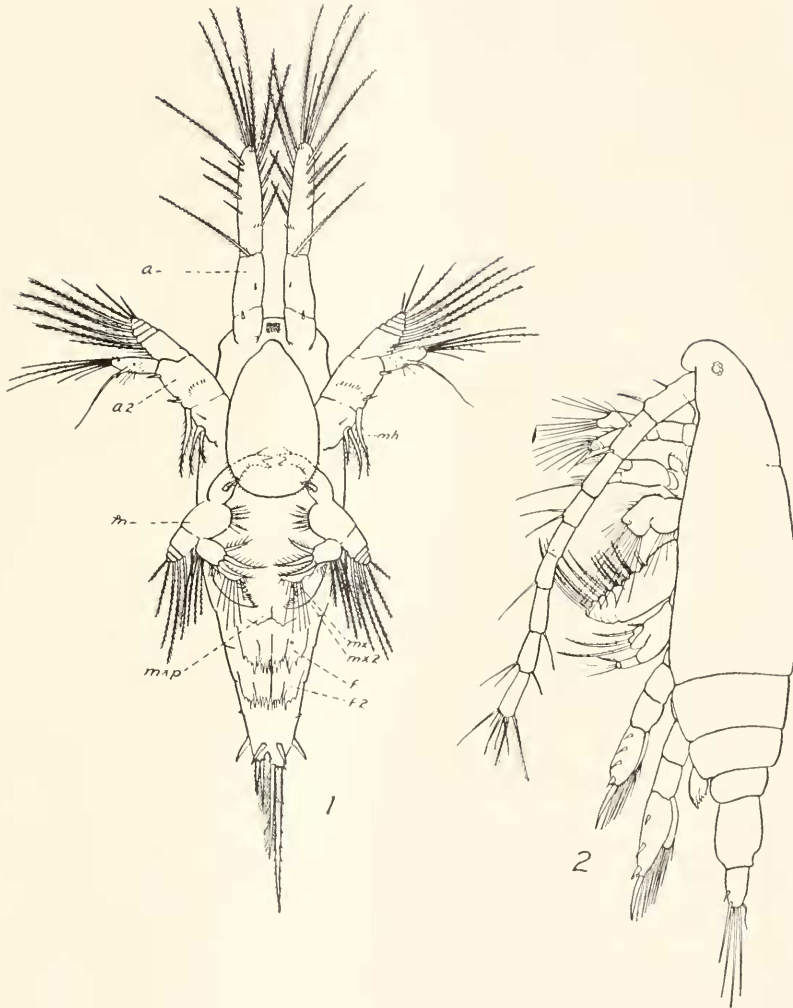
Length 0.498–0.590 mm. (average of 5 measurements 0.543 mm.) to the end of caudal rami. Thorax¹ of four segments, abdomen of one segment. The abdomen and caudal rami are symmetrical and each ramus bears four long terminal setae, one short lateral seta (which in the later stages assumes the character of the regular terminal seta), and one dorsal seta. Dorsal cuticular lenses are poorly defined and partially surrounded by pigment bodies. The rostral processes which are typical of the later stages are wanting, the rostrum being only a rounded blunt protuberance.

First Antenna.—Nine evident segments.

Second Antenna.—First basipod with one seta. Second basipod with two setae. Endopod of two segments, the first fused with the second basipod, and bearing two outer setae, the second segment forming a lateral and a terminal lobe each bearing a distinct group of setae indicating the fusion of two segments homologous to the two clearly defined end segments of the endopod of the mandible. The lateral lobe bears a group of three setae, and the terminal lobe, six setae. The exopod consists of five evident segments, the first short and bearing one inner seta, the second long and bearing three setae. The remaining end segments are short and very obscure and bear a total of eight setae.

¹ The term 'thorax' used in connection with these species designates that portion of the body bearing visible feet plus the next segment to the posterior. Thus the adult animal is considered to possess a total of six thoracic segments of which the genital segment is the last to appear.

PLATE II



Labidocera trispinosa

FIG. 1. Nauplius Stage VI.

FIG. 2. Copepodid Stage I, lateral.

Abbreviations: a—first antenna.
 a2—second antenna.
 f—first legs.
 f2—second legs.
 m—mandible.

mh—masticatory hook of second
 basipod.
 mx—first maxilla.
 mx2—second maxilla.
 mxp—maxilliped.

Mandible.—Mandibular blade with four teeth, a small spine, and several fine short setae. Palp with a very short first basipod; a long second basipod with four slender setae; an endopod of two short segments, the first with a distal group of four long setae, and the second with a terminal group of six long setae; an exopod of five segments, 1-4 with one long seta each and the fifth with two shorter slender setae.

First Maxilla.—The structure of this appendage is like that of the adult except for less obvious segmentation and smaller number of setae on certain lobes. Gnathobase or first inner lobe with eleven short spines; second inner lobe with three long strong setae; epipod or outer setiferous plate bears four long slender setae; the third inner lobe situated on a very short segment bears three long setae, while the outer margin of this segment bears a single long seta. The following segment bears three slender inner setae and is fused with the first segment of the exopod which bears three lateral setae. The second or terminal segment of the exopod bears five long coarse setae. Endopod of two poorly defined segments, the terminal one with seven long coarse setae.

This appendage is identical with that of *Labidocera jolla* which is figured for the adult in Plate IV, Fig. 13.

Second Maxilla.—Uniramose and strongly built. First basipod with two endites each bearing one short and one long seta and a number of fine spines at their bases. Second basipod with two endites each with one short and two long setae; the first endite also bears a number of very fine spines. Endopod of five poorly defined segments, the first segment slightly the longest and bearing one long and one short seta, segments 2-4 each with one long seta, and the fifth segment with one long and one short seta. All the setae of the appendage are strong and coarsely setose.

Maxilliped.—Uniramose. The first basipod enlarged and consisting of three lobes, the first with one short setose seta, the second with one long and one short setose seta, the third with one long setose seta. The second basipod is narrow and bears no setae. Endopod of two segments, the first with one distal plumose seta, the second with three terminal smooth setae.

First Leg.—First and second basipod with no setae. Endopod of one segment with seven setae. Exopod of one segment with four outer spines, a terminal blade and three setae.

Second Leg.—First and second basipods with no setae. Endopod of one segment with six setae. Exopod of one segment with three outer spines, a terminal blade and three setae.

Third Leg.—Rudimentary.

Copepodid Stage II

Length 0.720–0.797 mm. (average of 5 measurements, 0.767 mm.). Thorax of five segments, abdomen of one segment. Dorsal cuticular lenses and rostral processes present. Urosome and caudal rami symmetrical.

First Antenna.—Fourteen segments.

Second Antenna.—As in I but with five setae on the lateral lobe and six setae on the terminal lobe of the distal segment of the endopod.

Mandible.—As in I but with five mandibular teeth, and with six setae on the terminal segment of the endopod.

First Maxilla.—As in I but with six setae on the epipod and four setae on the third inner lobe.

Second Maxilla.—As in I.

Maxilliped.—As in I but with two short setae on the first lobe of the first basipod; and with an endopod of three segments, the first with one long and one short plumose seta, the second with one long plumose seta, and the third with three long smooth setae.

First Leg.—First basipod with one inner seta; second basipod with no seta. Endopod of one segment with eight setae. Exopod of two segments, the first with one outer spine, the second with three outer spines, a terminal blade, and four setae.

Second Leg.—First basipod with one seta; second basipod with no seta. Endopod of one segment with eight setae. Exopod of two segments, the first with one outer spine, the second with two outer spines, a terminal blade, and four setae.

Third Leg.—First and second basipods with no setae. Endopod of one segment with six setae. Exopod of one segment with three outer spines, a terminal blade, and three setae.

Fourth Leg.—Rudimentary.

Copepodid Stage III

Length 1.03–1.11 mm. (average of 5 measurements 1.064 mm.). Thorax of six segments, abdomen of one segment. Posterior end of body symmetrical.

First Antenna.—Nineteen segments.

Second Antenna.—As in II.

Mandible.—As in II.

First Maxilla.—As in II but with eight setae on the epipod and four setae on the first segment of the endopod.

Second Maxilla.—As in II.

Maxilliped.—As in II but with two short plumose setæ at the base of the one long seta on the third lobe of the first basipod, and with an endopod of five segments. The first segment of the endopod is very short and indistinctly defined and bears two long plumose setæ; the second segment is long and bears one plumose seta; the third and fourth segments are shorter and each bear distally one plumose seta; the fifth segment is very short and terminates in three smooth setæ.

First Leg.—First basipod with one inner seta; second basipod with no seta. Endopod of one segment with nine setæ. Exopod of two segments, the first with one outer spine and one inner seta, the second with three outer spines, a terminal blade and four setæ.

Second Leg.—First basipod with one inner seta; second basipod with no seta. Endopod of one segment with nine setæ. Exopod of two segments, the first with one outer spine and one inner seta, the second with three outer spines, a terminal blade and five setæ.

Third Leg.—First basipod with one inner seta; second basipod with no seta. Endopod of one segment with eight setæ. Exopod of two segments, the first with one outer spine, the second with two outer spines, a terminal blade, and four setæ.

Fourth Leg.—First and second basipods with no setæ. Endopod of one segment with six setæ. Exopod of one segment with three outer spines, a terminal blade and three setæ.

Fifth Leg.—Rudimentary.

Copepodid Stage IV

Length female 1.34–1.49 mm. (average of 8 measurements, 1.40 mm.); male 1.23–1.41 mm. (two specimens). Thorax of six segments, abdomen of two segments. The corners of the fifth thoracic segment are symmetrical and slightly pointed, and the urosome is also symmetrical.

First Antenna.—Twenty-three segments.

Second Antenna.—As in III but with seven setæ on the lateral lobe of the terminal segment of the endopod, and with an additional slender seta on the terminal segment of the exopod.

Mandible.—As in III but with seven setæ on the terminal segment of the endopod.

First Maxilla.—As in III but the epipod and exopod each with nine setæ.

Second Maxilla.—As in III but with the addition of two setæ at the base of the two long setæ on the first endite of the first basipod.

Maxilliped.—As in III but with an additional small seta at the base of the two longer setæ on the second lobe of the first basipod. The second basipod is finely serrate on the anterior surface, and there are

now two plumose setae on the distal end of the second segment of the endopod.

This appendage is now essentially the same as in the adult stage (Plate IV, Fig. 23). The short first segment of the endopod, however, becomes so obscure by fusion to the second segment in the later stages that the endopod appears to have only four segments.

First Leg.—First basipod with one inner seta; second basipod with no seta. Endopod of one segment with nine setae. Exopod of two segments, the first with one outer spine and one inner seta, the second with three outer spines, a terminal blade, and four setae.

Second Leg.—First basipod with one inner seta; second basipod with no seta. Endopod of one segment with ten setae. Exopod of two segments, the first with one outer spine and one inner seta, the second with three outer spines, a terminal blade, and five setae.

Third Leg.—First basipod with one inner seta; second basipod with no seta. Endopod of one segment with nine setae. Exopod of two segments, the first with one outer spine and one inner seta, the second with three outer spines, a terminal blade, and five setae.

Fourth Leg.—First basipod with one inner seta; second basipod with no seta. Endopod of one segment with eight setae. Exopod of two segments, the first with one outer spine, the second with three outer spines, a terminal blade, and five setae.

Fifth Legs, Female (Plate IV, Fig. 14).—Biramose, small and symmetrical. The second basipod bears on its posterior surface a short plumose seta. Endopod represented by a short smooth segment. Exopod of one segment with one outer spine near the middle and one near the tip. At the tip there is one terminal spine and adjacent to it on the inner side is a very small spine which in the later stages develops into the larger terminal point.

Fifth Legs, Male (Plate IV, Fig. 19*a*).—Biramose and asymmetrical. The second basipod and the endopod are like the corresponding parts in the female. Right exopod slightly longer than the left and with two segments indicated. Each exopod bears two small outer spines and a terminal point.

In this stage the sexes apparently can be distinguished only by the structure of the fifth legs.

Copepodid Stage V

Length, female 2.04–2.06 mm. (three measurements). Thorax of six segments, abdomen of two segments. The fifth thoracic segment with sharply pointed corners. Posterior portion of body symmetrical and without protuberance on genital segment. No males were found of this species in this stage.

First Antenna.—Twenty-three segments discernible.

Second Antenna.—As in IV.

Mandible.—As in IV with setae of terminal endopod segment increased to eight.

First Maxilla.—Segmentation more defined and increased strength of armature.

Second Maxilla. As before but with a total of five setae on the first endite of the first basipod.

Maxilliped.—No change in structure.

First Leg.—First basipod with one inner seta; second basipod with no seta. Endopod of two segments, the first with three inner setae, the second with six setae. Exopod of three segments, the first and second with one outer spine and one inner seta, the third with two outer spines, a terminal blade, and four setae.

Second Leg.—First basipod with one inner seta; second basipod with no seta. Endopod of two segments, the first with three inner setae, the second with eight setae. Exopod of three segments, the first and second with one outer spine and one inner seta, the third with three outer spines, a terminal blade, and five setae.

Third Leg.—First basipod with one inner seta; second basipod with no seta. Endopod of two segments, the first with three inner setae, the second with eight setae. Exopod of three segments, the first and second with one outer spine and one inner seta, the third with three outer spines, a terminal blade, and five setae.

Fourth Leg.—First basipod with one inner seta; second basipod with no seta. Endopod of two segments, the first with three inner setae, the second with seven setae. Exopod of three segments, the first and second with one outer spine and one inner seta, the third with three outer spines, a terminal blade, and five setae.

Fifth Leg, Female (Plate IV, Fig. 15).—Similar to Stage IV, with the small inner terminal spine enlarged to a heavy terminal point.

Copepodid Stage V, Adult

The original description given for the adult stage of this and the following species is not complete. It is therefore desirable to include here also brief descriptions of this stage.

Female (Plate V, Fig. 1).—Length 2.50–2.82 mm. (average of 7 measurements, 2.81 mm.). The measurements given by Esterly (1905, p. 202) for the adult female is 1.6 mm.; only a little greater than is here given for copepodid Stage IV. The structure of the adult appendages and body segmentation is essentially the same as in Stage

V. In Plate IV are figured the fifth legs (Fig. 16), the mandible (Fig. 12), and the maxilliped (Fig. 23). The last two named appendages are the same in both sexes.

Male (Plate V, Fig. 2).—Length 2.14–2.47 mm. (average of 7 measurements, 2.31 mm.). This agrees rather closely with Esterly's maximum figure which is 2.2 mm. The abdomen consists of four segments. The right posterior corner of the fifth thoracic segment is produced into a slender curved spine, and adjacent to it on the posterior margin on the same side there are two to three smaller spines. Esterly (1905, p. 202) notes only two such spines. The fifth legs (Plate IV, Fig. 22) are as in the original description but with a rudimentary endopod on the left foot.

LABIDOCERA JOLLÆ

The adults of *Labidocera jollæ* and *Labidocera trispinosa* are easily distinguished by sharply defined characters, but the nauplius larvae of the species are very similar and can be distinguished only by small but yet definite differences.

Each developmental stage of *Labidocera jollæ* was also worked out carefully and will be briefly compared with those of *Labidocera trispinosa* in all the essential characters, stressing mainly the points of difference.

Nauplius Stage I was not found or could not be distinguished from the corresponding stage referred to *L. trispinosa*. (The nauplius examined was referred to this species in view of its greater numbers.) A study of the following nauplius stages will show that the separation of the two species in Stage I must depend mainly, if not wholly on the comparative slenderness of the masticatory hooks occurring on the first and second basipod of the second antenna. These hooks are only weakly developed in this stage.

In the following nauplius stages *L. jollæ* is usually slightly the larger of the two species, the first antennæ and the long caudal spine are relatively shorter, and the pigmentation of the body is more pronounced and of a definite blue-green cast. When at rest the first antennæ are directed straight forward.

Nauplius Stage II (Plate III, Fig. 1)

Length 0.200–0.211 mm. (two specimens measured). The anatomical feature distinguishing the species in this stage is a very slender masticatory hook on the second basipod of the second antenna as compared with the heavy, well developed corresponding hook in *L. trispinosa* (Plate IV, Figs. 1 and 2, *mh*). That this character is a

constant one is supported by its persistence in combination with other specific characters that will be mentioned for the later stages. The short spine appearing on the distal portion of the second basipod of the second antenna of *L. trispinosa* is wanting in *L. jollæ*. Its first appearance is in Stage III. This spine and also the other spines occurring on the second antenna are more slender in the latter species in all stages.

Nauplius Stage III

Length 0.260–0.270 mm. (three measurements). The only additional difference in this stage is the appearance of a transverse series of very minute spines on the second basipod of the second antenna. In *L. jollæ* the series is located on the distal half of the segment while in *L. trispinosa* it is on the proximal half. This difference persists throughout all of the stages but in the older larvæ a few similar small spines appear also on the proximal half of the segment in *L. jollæ*.

Nauplius Stage IV

Length 0.265–0.319 mm. (average of six measurements 0.304 mm.). In this stage the development of the larval chewing process is completed in both species. In *L. jollæ* the process terminates in three teeth and a small spine, while in *L. trispinosa* it terminates in only two teeth and a small spine (Plate I, Fig. 4, *cp*; Plate IV, Figs. 3 and 4). The greater number of mandibular teeth in the former species is reflected in the copepodid stages, in the first of which the number is in the same ratio as in the nauplius stage.

Nauplius Stage V

Length 0.390–0.426 mm. (average of five measurements 0.398 mm.). No added specific changes.

Nauplius Stage VI (Plate III, Fig. 2)

Length 0.424–0.495 mm. (average of eleven measurements, 0.472 mm.).

In this stage there appears an additional short dorsal marginal seta on the distal segment of the first antenna, bringing the total number of dorsal marginal setæ in *L. jollæ* to seven, whereas in *L. trispinosa* the total number in this stage is six, the same as in the fifth nauplius stage.

The Copepodid Stages

In the first copepodid stage of *Labidocera jollæ*, the cephalic hooks and also the rostral processes are wanting. Hence in this stage it is

PLATE III

*Labidocera jolla*

FIG. 1. Nauplius Stage II.

FIG. 2. Nauplius Stage VI.

FIG. 3. Copepodid Stage II, dorsal.

Abbreviation: *mh*—masticatory hook of second basipod.

practically indistinguishable from the same stage in *L. trispinosa* except for small differences occurring in the mandibular blade and in the endopod of the maxilliped. In the former species the mandibular blade bears six teeth as compared with only four in the latter species, and in the former the terminal segment of the endopod of the maxilliped bears but two smooth setae, while in the latter it bears three smooth setae. These distinctions remain evident through all of the stages, but in Stage II each species acquires an additional tooth on the mandibular blade, giving the total number found in the adult animal (Plate IV, Figs. 11 and 12). In all of the copepodid stages *L. jollae* is relatively more green in color. The development of the appendages and the body segmentation is the same in both species for corresponding stages.

In the second copepodid stage (Plate III, Fig. 3), *L. jollae* acquires the rostral processes and also the cephalic hooks. The presence of cephalic hooks serves as a reliable and easy distinction between the species in this and all the following stages.

The sexes are first distinguishable in the fourth copepodid stage by the structure of the fifth legs. The development of these legs is shown for the female copepodid IV and VI in Plate IV, Figs. 17 and 18 respectively. In Stage V, not figured, the legs are almost identical with those shown for Stage VI. In Plate IV, Figs. 19 to 21, is given the development of the male fifth legs from Stage IV to VI.

EXPLANATION OF PLATE IV

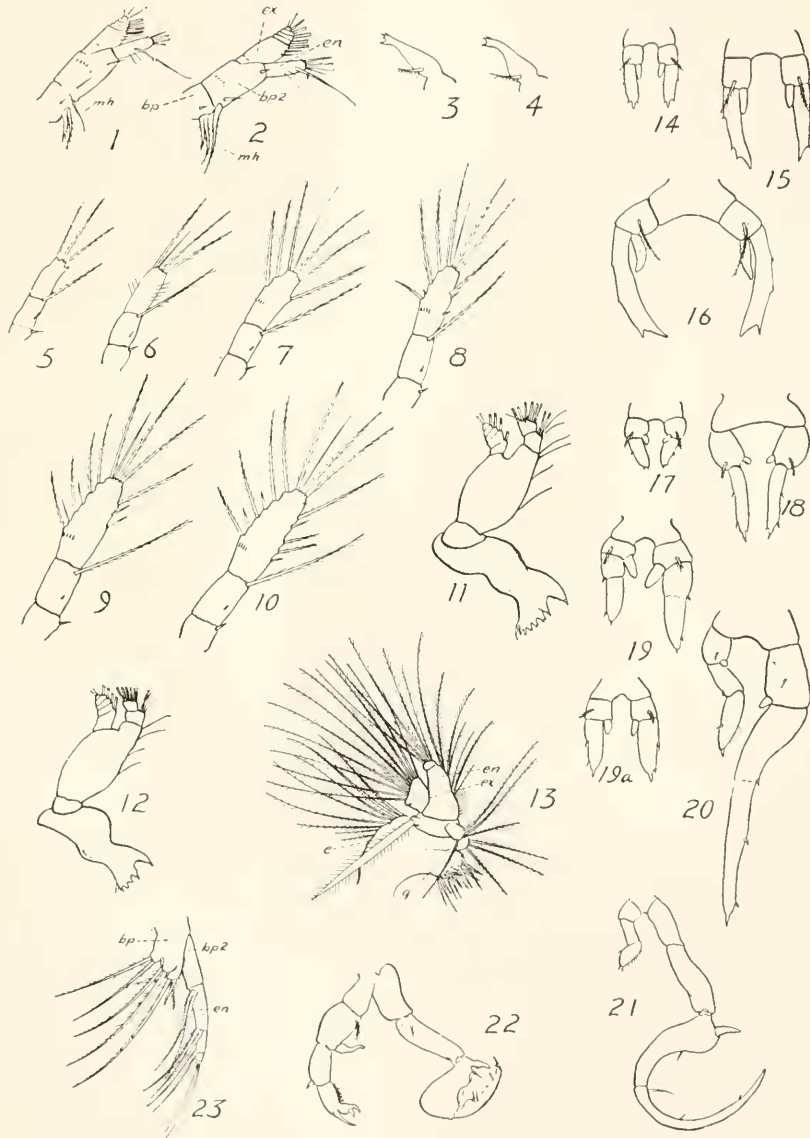
Labidocera trispinosa and *L. jollae*.

- FIG. 1. *L. jollae*, second antenna.
 FIG. 2. *L. trispinosa*, second antenna.
 FIG. 3. *L. jollae*, chewing process.
 FIG. 4. *L. trispinosa*, chewing process.
 FIGS. 5-10. *L. trispinosa*, first antenna nauplius Stages I-VI.
 FIG. 11. *L. jollae*, adult mandible.
 FIG. 12. *L. trispinosa*, adult mandible.
 FIG. 13. *L. jollae*, adult first maxilla.
 FIG. 14. *L. trispinosa*, female fifth legs, copepodid Stage IV.
 FIG. 15. *L. trispinosa*, female fifth legs copepodid Stage V.
 FIG. 16. *L. trispinosa*, female adult fifth legs.
 FIG. 17. *L. jollae*, female fifth legs, copepodid Stage IV.
 FIG. 18. *L. jollae*, female adult fifth legs.
 FIG. 19. *L. jollae*, male fifth legs, copepodid Stage IV.
 FIG. 19a. *L. trispinosa*, male fifth legs, copepodid Stage IV.
 FIG. 20. *L. jollae*, male fifth legs, copepodid Stage V.
 FIG. 21. *L. jollae*, male adult fifth legs, (reduced scale).
 FIG. 22. *L. trispinosa*, male adult fifth legs, (reduced scale).
 FIG. 23. *L. trispinosa*, adult maxilliped.

Abbreviations: *bp*—first basipod *en*—endopod
 bp2—second basipod *ex*—exopod
 e—epipod *g*—gnathobase
 mh—masticatory hook of second basipod

A comparison of body sizes shows that during the nauplius and early copepodid stages, *L. jolla* is slightly larger than *L. trispinosa*. In copepodid Stages IV and V the measurements are about equal, but in the adult stage the latter is a little longer.

PLATE IV



The adult of *L. jollæ* agrees essentially with the original description given by Esterly (1906, p. 74).

Female.—Length 2.49–2.67 mm. (average of nine measurements, 2.57 mm.). In this stage the urosome is very asymmetrical (Plate V, Fig. 8), an asymmetry which is first indicated only in the broadening of the right caudal ramus of Stage V (Plate V, Fig. 7).

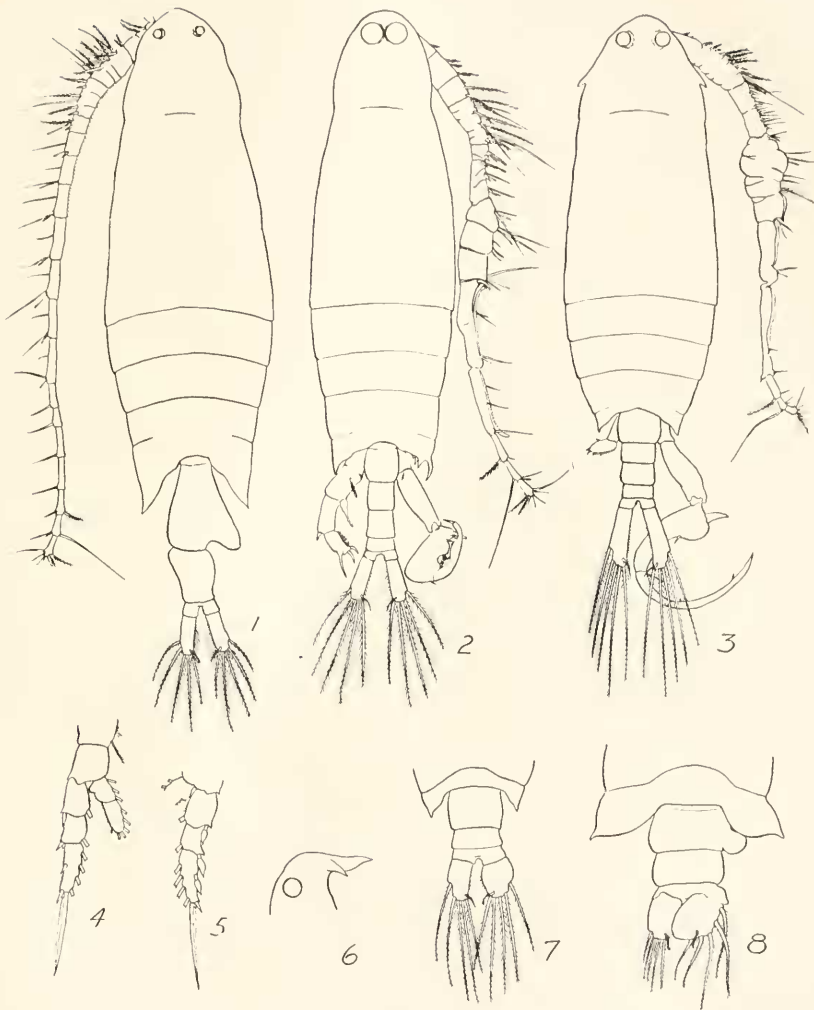
Male.—Length 2.06–2.39 mm. (average of twenty-eight measurements, 2.20 mm.). The rostrum is asymmetrical due to the right prong being much reduced (Plate V, Fig. 6). Esterly also noted this asymmetry but was not certain if it should be considered an individual deformity or a distinct character, since his description was based on a single specimen. I have examined many adult males and find this peculiar asymmetry to be constant in every specimen examined. In the fifth copepodid stage the male rostrum is, however, symmetrical. Another unusual asymmetry found only in the adult male is evident in the modification of the outer spines occurring on the exopod of the right first leg (Plate V, Fig. 5). These are broader and more leaf-like than the regular outer spines found on the other swimming legs (Plate V, Fig. 4).

REMARKS

It has been shown by different workers that the nauplius larvæ of marine copepods belonging to the same genus are, as one might expect, strikingly similar, and may in some instances be identical, as is shown by Oberg (1906) and Gurney (1931) for *Acartia longiremis*, *A. bifilosa*, and *A. clausi*.

In view of the great likeness found in the larvæ of related copepods, the two larvæ herein described are doubtless typical of the genus *Labidocera* and, perhaps with some modifications, of the whole family *Pontellidæ*. Thus far, however, we have information on only three genera of the group, namely, *Labidocera*, *Epilabidocera* (syn. *Paralabidocera*), and *Pontella* (incomplete). The larvæ of the present species of *Labidocera* are very similar to the corresponding stages of *Epilabidocera amphitrites* recently described (Johnson, 1934b), and judging from the few figures given by Claus (1893) for *Pontella mediterranea* there appears to be here also essential agreement as to type. An elongated body is common to the three genera, though much accentuated in *Pontella*. The arrangement and type of caudal armature is the same in the investigated species of *Labidocera* and *Epilabidocera*, and agrees with *P. mediterranea* but for the exaggerated size of the left terminal spine in the latter. The first antennæ of the three genera agree as to segmentation and shape and the armature of

PLATE V

*Labidocera trispinosa* and *L. jollæ*

- FIG. 1. *L. trispinosa*, adult female, dorsal.
 FIG. 2. *L. trispinosa*, adult male, dorsal.
 FIG. 3. *L. jollæ*, adult male, dorsal.
 FIG. 4. *L. jollæ*, adult male left first leg.
 FIG. 5. *L. jollæ*, adult male exopod right first leg.
 FIG. 6. *L. jollæ*, adult male head, lateral.
 FIG. 7. *L. jollæ*, female copepodid V posterior end, dorsal.
 FIG. 8. *L. jollæ*, adult female posterior end, dorsal.

TABLE I
 Identification Table for *Nauplius* Stages of *Labidocera trispinosa* and *L. jollae*

Stage	I	II	III	IV	V	VI
Length in mm.	0.130-0.140	0.175-0.201	0.215-0.271	0.250-0.325	0.310-0.370	0.360-0.420
	—	0.200-0.211	0.260-0.270	0.265-0.319	0.390-0.426	0.424-0.495
<i>L. trispinosa</i>	3 terminal setae	4 terminal setae, 1 dorsal and 1 ventral series of fine hairs	4 terminal setae, 2 dorsal and 1 ventral marginal setae (fine hairs wanting)	As in III, but 4 dorsal and 3 ventral marginal setae	As in IV, but 6 dorsal and 3 ventral marginal setae	As in V, but 6 dorsal and 5 ventral marginal setae
<i>L. jollae</i>	—	As above	As above	As above	As above	As above, but 7 dorsal and 5 ventral marginal setae
Caudal Armatore	2 small end spines	1 long end spine and 1 shorter end seta	1 long and 1 short end spine, 2 end setae, and 1 pair ventral hooks	As in III	As in IV, but also 1 pair lateral hooks	As in V
First Maxilla	0	0	Bud	Bud	Rudimentary	Rudimentary
Second Maxilla	0	0	0	Bud	Bud	Rudimentary
Maxilliped	0	0	0	0	Bud	Bud
First and second legs	0	0	0	0	0	Rudimentary

TABLE II
 Identification Table for Copepodid Stages of *Labidocera trispinosa* and *L. jollae*

Stage.....	I	II	III	IV	V	VI
<i>L. trispinosa</i>	0.498-0.590	0.720-0.797	1.03-1.11	1.34-1.49 ♀ 1.23-1.41 ♂	2.04-2.06 ♀	2.50-2.82 ♀ 2.14-2.47 ♂
<i>L. jollae</i>	0.570-0.650	0.855-0.990	1.20-1.215	1.34-1.50 ♀ 1.35-1.43 ♂	1.97-2.00 ♀ 1.71-1.78 ♂	2.49-2.67 ♀ 2.06-2.39 ♂
<i>L. trispinosa</i>	Rostral processes and cephalic hooks wanting	Rostral processes present, cephalic hooks wanting	As in II	As in III	As in IV	As in V
<i>L. jollae</i>	Rostral processes and cephalic hooks wanting	Rostral processes and cephalic hooks present	As in II	As in III	As in IV	As in V
Thoracic Segments.....	4	5	6	6	6	6
Abdominal Segments.....	1	1	1	2	2 ♀ 3 ♂	2 ♀ 4 ♂
Mandibular teeth	4	5	5	5	5	5
<i>L. jollae</i>	6	7	7	7	7	7
Legs present.....	1st and 2nd (3rd rudimentary)	1st, 2nd, and 3rd (4th rudimentary)	1st, 2nd, 3rd and 4th (5th rudimentary)	1st, 2nd, 3rd, 4th and 5th (modified)	As in IV	As in V

at least the species of *Labidocera* and *Epilabidocera* is essentially the same. The number of ventral marginal setae is the same in all three species, but *E. amphitrites* possesses a total of eight dorsal marginal setae, as opposed to seven in *L. jollae* and six in *L. trispinosa*. An alternation of long and short setae in the dorsal marginal series is common to all three species. It is also characteristic of the living larvae of all three species to hold the first antennae extended straight forward and in contact when not swimming.

In Tables I and II are given the characters most useful in identification of the various nauplius and copepodid stages.

SUMMARY

1. The developmental stages of *Labidocera trispinosa* and *L. jollae* are described and figures given.

2. Each species passes through the typical six nauplius and six copepodid stages.

3. It is probable that in the first nauplius stage the species are indistinguishable.

4. In the adult condition the species are sharply distinguished, but during the second to sixth nauplius stages and during the first copepodid stage they are separable only by small but yet definite characters, the most useful of these being the type of masticatory hook occurring on the second basipod of the second antenna.

5. Specific identification of the nauplius larvae was established by experimentally rearing the sixth nauplius stage through metamorphosis.

6. Tables I and II are given to facilitate identification of the nauplius and copepodid stages.

7. The nauplius larvae of *Labidocera* are very similar to the larvae of *Epilabidocera* and are believed to typify the nauplius larvae of at least other nearly related genera of Pontellidae.

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